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Mapping and Constraints Analysis of Mung Bean Value Chain in Punjab, Pakistan

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Pulses are important in terms of food and nutritional security in developing countries. Especially mung beans have significant nutritional and economic value in the food value chain of Pakistan. They are an important source of protein, fiber, vitamins, minerals, folate, iron, and potassium, thereby contributing to nutritional security. This study examined the value chain and marketing issues of mung beans in Punjab, Pakistan. Mung bean growers and other stakeholders earn less than the potential due to several issues along the whole value chain. Being its importance and future potential, the present policy paper was designed. The sample was selected using a multistage sampling technique to collect data from 200 respondents. Focus group discussions were conducted prior to the survey for refining the questionnaire and identifying major constraints. Standard value-chain mapping procedures were applied to document production, aggregation, processing, and marketing flows. Both primary and secondary data sources were triangulated to enhance the reliability of findings. The Likert-scale constraints were subjected to diagnostic tests, including the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity, to confirm sampling adequacy before Principal Component Analysis (PCA). PCA was then used to extract and categorize constraint clusters, with factor loadings rotated using the varimax method to improve interpretability. Results indicate that technology is the most critical constraint in the mung bean value chain, followed by production-related, financial/economic, marketing, and standardization constraints. The study highlights the need for government and private sector support to enhance technical capacity, market efficiency, and value-added processing for the sustainability of mung bean growers and other stakeholders.
Keywords: Sustainable livelihoods**,** mung beans, PCA, value chain analysis, Pakistan.

INTRODUCTION

Food systems are complexly interlinked with complicated biological, environmental and socioeconomic factors. Food systems are transforming and changing at great pace globally (Moallemi et al., 2025). Global food demand is expected to be doubled by 2025 because of the rapid population growth rate, urbanization, and consumer preferences (Tijjani and Khairulmazmi, 2021). Global demand for nutrient-dense and climate-resilient food crops has grown substantially due to rapid population increase, urbanization, changing dietary patterns, and pressures on natural resources (Kunlere, 2025). As most of the world's food suppliers are small-scale farmers of developing nations. They often face hurdles and challenges to accessing domestic, national, and international markets. The global food demand in 2025 is projected to reach around 4.5-5 billion tons of cereals, pulses, fruits, vegetables, and meat combined, reflecting continued growth from population increase and dietary shifts. Global population is expected to be around 8.1 billion in 2025, up from 7.9 billion in 2023, fueling higher food demand (FAO, 2022). By 2030 the global food demand expected to increase by 20-25% over 2020 levels and By 2050 estimated 35-50% increase in total food demand due to population reaching ~9.7 billion and rising per capita consumption (OECD, 2023).

So, there is a need to strengthen the food value chain. Food value chains are important to achieve the sustainable development goals considering the important role agricultural value chains play in alleviating poverty and improving nutritional status. The value chain analysis and efficiency assessment are important for better policy formulation and assessment of the potential and critical bottlenecks of specific nodes, along with identification and upgrading strategies that will maximize the net benefits of all actors.

Globally, pulses are one of the important food crops due to their higher nutrition value (Global Pulse Confederation)

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Pulses belongs to legume family of plants. Another important aspect of pulses is that they contribute to sustainable growth through enhancing soil health, reducing greenhouse gases emission and using less water compared to other crops. Pulses are a valuable commodity for both export and import around the world (Shaikh et al., 2019). Pulse crops are grown on 85.63 million hectares worldwide, producing 77.59 million tones and yielding 906 kilograms per hectare. India is the world's largest producer, comprising almost 92 percent of production among SAARC countries, followed by Pakistan four percent and Bhutan one percent (Bradl, 2008).

In Pakistan, pulses are grown as minor crop and covers only five percent of cropped area (PARC, 2016) and there are great concerns regarding the production area along with other major crops. The winter main pulse crop is chickpeas, as is lentils (masoor) and are substitutes for wheat, oats, barley and maize. Pulse crop in summer include mung beans and mash beans and compete with cotton, sugarcane, rice and maize. But they are not close substitute due to low profitability. The current yield of Pulses is 0.4t/ha for chickpeas which is very low as compared to yield in India (1.0t/ha), and United States (1.4t/ha), Myanmar (1.5t/ha) and Australia (1.2t/ha) (FAO, 2017).

The pulses production has showed a declining trend in last ten years and is not meeting the consumption requirement due to which a considerable amount is imported to meet the consumption. The planted area is almost constant around 2.8 million acres (AMIS, 2017). There are number of constraints that are causing low production and stagnant area of pulses in Pakistan. A few include competition with cereal and cash crops, use of adulterated and improperly managed seed, lack of efficient production technology and lack of training of women managing the seed at home (Kumar et al., 2013). Farmers are inclined to grow crops where yields and prices are relatively predictable; however, pulses farm gate prices are volatile, especially in competing with crops such as wheat and sugarcane, where the government operates a price stabilization mechanism. The area and share of major pulses produced in Pakistan is given below in the map in Fig. 1.

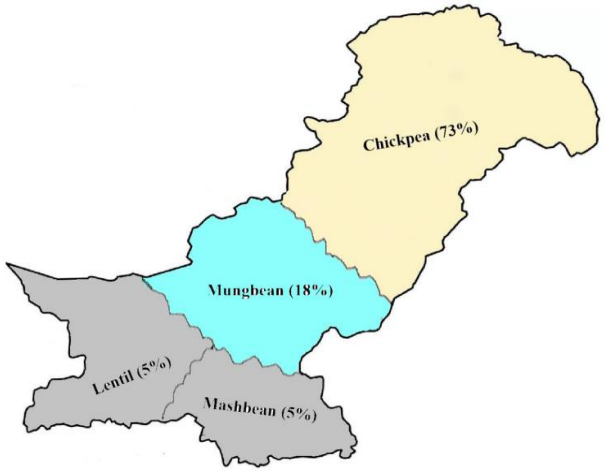

Figure 1. Area and share of major pulses grown in Pakistan (Ullah et al., 2020).

Problems in the pulses value chains are not limited to production practices only, rather extends to whole chain level. There are also post-production problems too, such as logistical inefficiency, post-harvest losses, lack of value addition and wastage and losses during transportation and marketing. Value chain analysis is vital for upgrading the value chain activities to enhance quality-based competitiveness of domestic agricultural commodities which leads to improved food security and poverty alleviation.

The dysfunctional value chain hinders the producers' profit and consumer utility. The production, processing, marketing, and socio-cultural constraints must be identified in the whole value chain with an integrated assessment approach considering the farming communities The improvement in value chain interlinkages and connectivity and availability of market information could lead to an increase in market functionalities at large and will enhance efficiency across the whole chain.

Among pulses, chickpea (Gram) produced on almost 83 percent of total area planted, followed by Mung bean (13 percent), and Mash and lentils (2 percent each). Mung bean is one of the important pulse crops of Pakistan and mostly cultivate in different regions of Punjab and Sindh. Punjab is the major mung bean growing province that alone accounts for 88 percent area and 85 percent of production. Cultivation is concentrated in the districts of Layyah, Bhakkar, Mianwali and Rawalpindi(JICA, 2013). In addition to the provide food, it also serves as cash crop of farming community. It also used as green manure so, it is preferred to grow by small landholding farmers.

Numerous previous studies focused on different aspects of food security, like the nutritional importance of pulses (Weinberger, 2005), nitrogen fixation of pulses (Herridge, 2009), the agricultural value chain analytics and Poverty alleviation at farm level (Kousar et al., 2019), the post-harvest

losses in value chain from the farm to fork (during production and processing of agricultural commodities) (Redlingshöfer et al., 2017), production constraints of pulses (Burman et al., 2006), Demand, supply and policy aspects of pulses in Pakistan (Rani et al., 2014). Only limited studies have investigated the constraints for strengthening the mung bean value chain. Keeping in view this research gap and important role mung bean value chains play in alleviating poverty, meeting SDGs of food and nutritional security there is a need to objectively assess the potential and critical bottlenecks of specific nodes in the chains to identify upgrading strategies that will maximize the net benefits of all actors. The article has also mapped the value chain of mung bean in Punjab, Pakistan. was done to collect data from the Mung bean growers in Jan-March, 2022. Figure 2 below presents the study area: group discussion based on the objectives of the study. Based on this information, survey.

MATERIALS AND METHODS

***Description of Study Area and Focus Group Discussion*:** For this study, firstly focus group discussion was conducted in the study area of District Layyah and Bhakkar. Three tehsils (Layyah Tehsil, Karor Lal Esan Tehsil and Chaubara tehsil) and two tehsils of Bhakkar (Bhakkar and Mankera) were selected. A group of 12 persons (Different stakeholders) were included in the focus group discussion considering the value chain actors, farmers, researchers, academia and farm families.

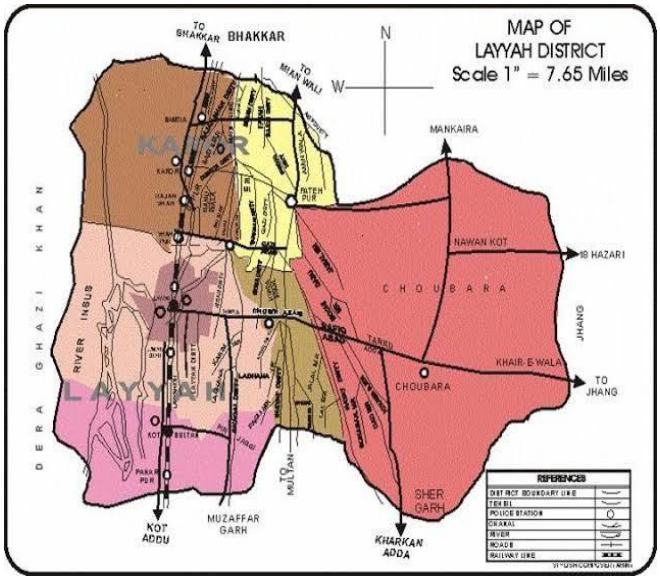

Figure 2. Map of the study area.

Data were collected through multistage random sampling technique by following the studies like Kousar and Abdulai (2015) and Kousar et al., (2019). Information about issues, problems and constraints of mung bean production, harvesting, cleaning, sorting, handling, grading, storage, packaging, processing and marketing were collected from a total of 200 growers, contractors, wholesaler and retailer etc. through structured questionnaires. Questionnaires consists of Likert scale questions that recorded the level of different constraints. The scale of constraints ranged from 1-5 tagged as the strongly disagree is 1 and strongly agree as 5.

Descriptive Analysis of Mung Bean Growers: The questionnaire was formulated

by conducting Focal group discussions with stakeholders in value chain order to determine the future research orientation, to formulate of research questionnaire and to easily judge the socioeconomic situations of farming community in the study area. Descriptive statistics of the important variables used the study are presented in Table 1 and 2.

Table 1. Descriptive statistics of important variables.

Variables	Minimum	Maximum	S. D
Distance from main road (km)	<1	20	41.2
Age in years	19	74	14.7
Education (Years)	0	14	4.4
Experience (Years)	1	52	23.3
Income (Rupees)	22500	200000	226627.3
Soil Quality (land is fertile =1, otherwise=0)	0	1	0.24

Table 2. Distribution of respondents on the basis of their total area under mung bean cultivation.

Area	Frequency	Percentage (%)
1 to 3 acres	90	45.0
4 to 6 acres	70	35.0
7 to 9 acres	30	15.0
10 acres or above	10	5.0
Total	200	100.0

Constraint Analysis: Several types of constraints were reported along the whole value chain of mung bean which might cause complications while data analysis. The study employed Principal Component Analysis (PCA) to identify the constraints. PCA aims to reduce the sum of the squared perpendicular distances to the axis of the principal component. PCA is used for analysis as the components are highly correlated and it handles the large number of correlated factors. It includes orthogonal conversion for an observation set of variables that are possibly correlated into values of linearly uncorrelated variables that is termed as principal components. It tends to decompose the correlation matrix with value ones on the diagonal. The observed variables, sum of diagonals and trace of the matrix determine the value of variance.

During the analysis the total number of principal components in the analysis is smaller or equal to the total number of observed variables. The 1st component always gets the highest variance and follows the next components. The principal components are orthogonal because they are the eigenvectors of the symmetric covariance matrix. The component scores are calculated using the weights from Eigenvectors. Figure 3 described the framework of constraint analysis in mung bean value chain.

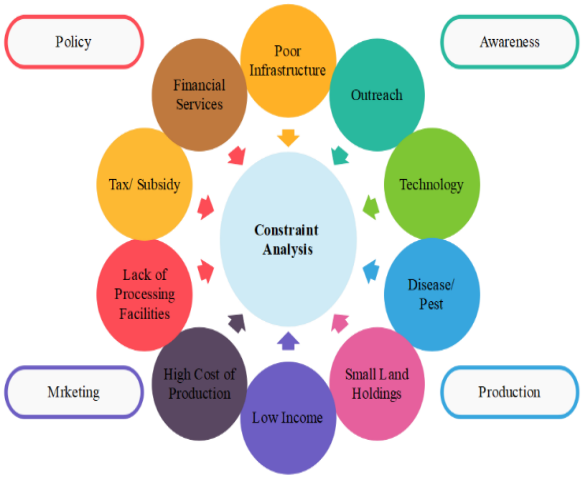

Figure 3. Framework of Constraint Analysis in Mung Bean Value Chain.

RESULTS

Mapping of Mung bean value chain in Punjab, Pakistan: The objective of mapping of marketing channel of mung bean is to provide a systematic knowledge of the flow of mung bean from producers to the end consumers. The simplest channel of distribution of mung bean is one originating at the farmers, going directly to the consumer. However, the involvement of other key players or market functionaries such as commission agents, dal mill owners/processor and wholesalers make the value chain of mung bean much more complex. However, the most popular channel of mung bean that was observedin the area under study is shown in Figure 4. Table 3 showed the BTS and KMO tests that explained the significance of components in PCA. The objective of PCA is to find out the common factors in linear combinations, called principal component and ranking them based on their importance. Eigen values of components are reported in Table 4. It shows that there are five components with more than one eigen values which represents 79.90 percent of the total variance. Only those factors whose eigenvalues are greater than one is retained in the analysis.

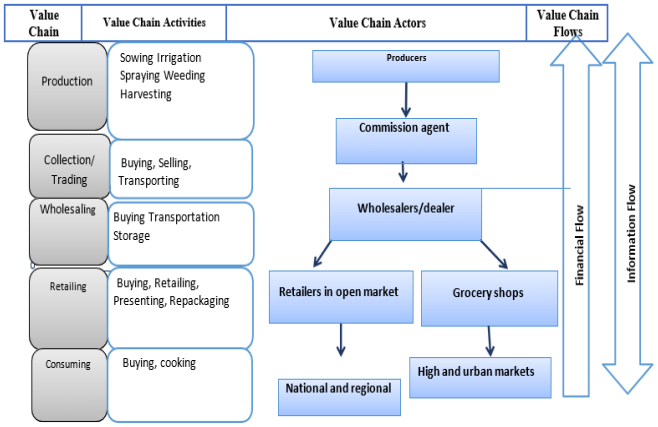

Figure 4. Structure map of mung bean value chain.

Empirical Findings of Constraint Analysis

Table 3. BTS and KMO tests.

Barlett Test of Sphericity Approx. (Chi-square)	479.05
KMO test for sampling adequacy	0.77
Degree of freedom	221
Significance	0.000

Table 4. Description of the variance explained by PCA in the analysis.

Component	Eigen value	Difference	Proportion	Cumulative
1	11.148	7.656	0.413	0.4129
2	3.492	0.047	0.129	0.5423
3	3.445	1.682	0.127	0.6698
4	1.762	0.401	0.065	0.7351
5	1.053	0.079	0.039	0.8246
6	0.973	0.084	0.036	0.8606
7	0.889	0.249	0.033	0.8936
8	0.639	0.066	0.024	0.9172
9	0.573	0.038	0.021	0.9385
10	0.535	0.218	0.019	0.9583
11	0.316	0.066	0.012	0.9700
12	0.250	0.043	0.009	0.9792
13	0.207	0.101	0.008	0.9869
14	0.106	0.017	0.004	0.9909
15	0.089	0.026	0.003	0.9941
16	0.063	0.025	0.002	0.9965
17	0.037	0.009	0.001	0.9978
18	0.027	0.008	0.001	0.9988
19	0.019	0.011	0.000	0.9995

The scree plot of eigenvalues in Figure 5 illustrates that only five factors have above the one eigenvalue, bench mark line in red color.

Table 5. Rotated component matrix.

Component		1	2	3	4	5
Lack of skilled labor	Technology	0.32				
Poor post-harvest operations		0.31				
Delaying harvesting		0.29				
Lack of information		0.28				
High cost of inputs	Production		0.40			
Output price fluctuation			0.34			
Unavailability of good quality seed			0.33			
Small size farm			0.31			
Pest/disease attack			0.32			
Lack of Govt. subsidy	Financial/Economic			0.31		
Poor access to financial services				0.30		
Low margins/income	Marketing				0.43	
Pre and post-harvest losses					0.40	
High cost of transportation					0.35	
Delay selling					0.34	
Lack of proper storage					0.28	
Unequal size of produce	Standardization					0.40
Unavailability of processing/grading machinery						0.38
Inappropriate packaging						0.34

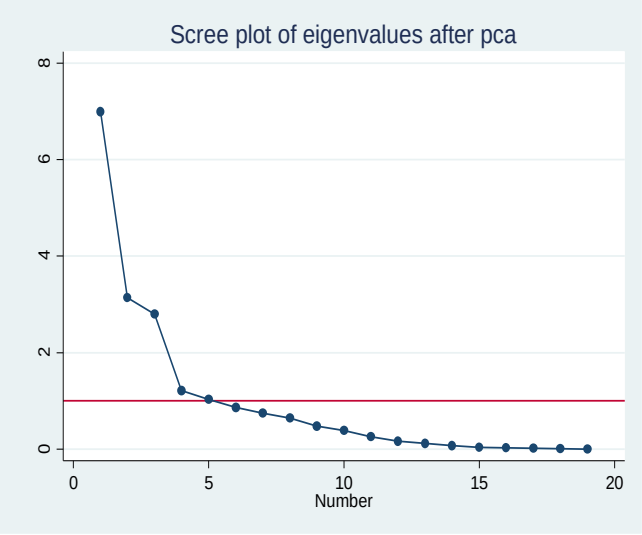

Figure 5. Scree plot of eigenvalues after PCA of mung bean.

Table 5 showed the rotated component matrix.

DISCUSSION

Mung bean is an important pulse crop. The provision of protein contents from pulses is better to that of wheat, such as amino acid as lysine, threonine, and tryptophan. It offers green manure as livestock sustain thus preferred to small landholding farmers. It is attainment fame as a turning round crop for cash income. This study examined the value chain and marketing issues of mung bean Punjab, Pakistan. In these areas, mostly the farmers are engaged in subsistence farming. Mung bean growers and other stakeholders are earning less than its potential due to the existence of several problems and constraints along its whole value chain. Keeping in view these constraints through the whole value chain and future export potential of mung bean, the present policy paper is designed.

The first component technology has an eigen value 11.15 and accounts for 41.29 percent of variance. The first component includes of four types of constraints. That includes lack of skilled labor, Poor post-harvest operations, delaying harvesting and lack of information. Lack of skilled labor has the highest factor loading with 0.32 value and lack of information have lowest value, 0.28. It has 0.875 Cronbach's alpha for this component that indicates the reliability of the cluster.

The next component entitled production factors with eigen value of 3.492 and 54.23 percent of variation explained by this factor including five items: high cost of inputs (0.40), Output price fluctuation (0.34 Unavailability of good quality seed (0.34), Small size farm (0.31) and pest and disease (0.32). Cronbach's alpha for this component yielded a value of 0.744, indicating the reliability of the cluster.

The third component explains the economic and financial factors in the mung bean value chain having an eigen value of 3.4 and 12.76 percent variation explained. This component comprises of two objects. These objects are lack of Govt. subsidy 0.31 and Poor access to financial services 0.30. The cluster is significant with 0.705 value of Cronbach's alpha.

Marketing factors is the fourth component having eigen value of 1.76297 and 73.51 percent of variation explained. This

component has five items: low margins/income 0.43, Pre and post-harvest losses 0.40h, high cost of transportation 0.35, delay selling 0.34, lack of proper storage 0.28. The 0.928 Cronbach's alpha for this component validated the reliability of the cluster. In Pakistan, post-harvest losses of mung bean are major concern, which is due to inefficiencies in warehouse, transferring and handling etc.

The standardization is the last component has eigen value of 1.05337 and 82 percent of variance. This component comprises of three items: Unequal size of produce 0.40, Unavailability of processing/grading machinery 0.38, inappropriate packaging 0.34. The Cronbach's alpha is 0.72 for this component. Standardization is very imperative for building degree in any process, but supply chain of most developing countries lacks standardization.

Comparison of Components: On the components of constraints analysis, the major constraint in mung bean industry is technology. It is very critical factor in production and marketing of agricultural commodities. This constraint is followed by production, financial/economic, marketing and process of standardization.

Conclusion and Policy Implications

This study employed multistage sampling technique to collect data from 200 respondents in 2022. Focus group discussion was conducted prior to survey and finalizing questionnaire. Mapping of mung bean value chain is done.

The study analyzes the constraints in value Chain of mung bean by employing Principal Component Analysis (PCA). Results of the constraint analysis of mung bean showed five components named as: "Technology", "Production", "Financial/Economic", "Marketing", and "Standardization". This depicted that the key constraint for the progress of mung bean is technology which is a critical factor. After technology, the most critical constraints are production, financial/economic, marketing and standardization. The findings of the study suggest government and private sector to provide financial and technical assistance to growers through the whole value chain of mung bean. Well-functioning market is the deer need of the study area. Information disseminating channels and processing/storage facilities should be provided at farm level in order to enhance margin of growers.

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***Conflict of interest*:** Authors declare that there is no conflict of interest.

***Ethical statement*:** This study was conducted in accordance with the ethical standards of social science research. Participation was voluntary, and confidentiality of respondents was ensured throughout the research process.

***Availability of data*:** Data is available on request from the authors.

Consent to participate: Participants were briefed about the objectives of the study, and informed consent was obtained for the use of their responses for research purposes only**.**

***Informed consent*:** Participants were briefed about the objectives of the study, and informed consent was obtained for the use of their responses for research purposes only.

***Consent for publication*:** N/A

SDGs addressed: No Poverty, Zero Hunger, Decent Work and Economic Growth, Responsible Consumption and Production, Climate Action (indirectly through sustainable farming practices).

***Policy referred*:** Regional Agricultural Development Policy; National Standards and Quality Assurance Policy; Sustainable Agricultural Practices Policy.

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